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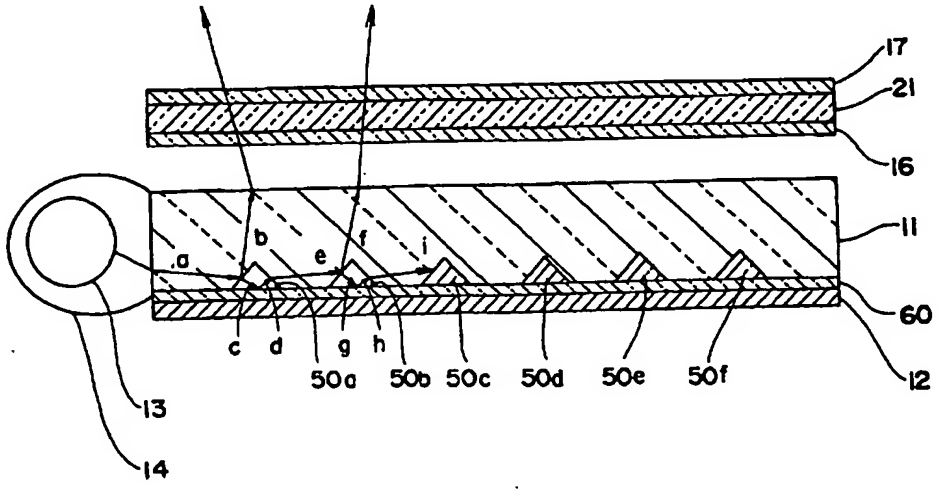
(54) Abstract Title
A backlight for a liquid crystal display

(57) A backlight unit comprising a plurality of prisms (50a-50f) arranged in between the light guide plate (11) and reflecting sheet (12), a lamp (13) projecting light from one side of the light guide plate and reflector (14) to condense the light. The prisms have a prism angle such that the angle between the angle of incidence of the light at the surface of the prism to the normal to the surface is the Brewster angle. The prisms are arranged so that they are parallel to the direction of the polarisation axis of the polarising plate (16) on the lower face of the liquid crystal panel. Polarization plates or films (eg polarization rotating plate 60) may be added to the back-light unit and reflecting members may be used instead of prisms.

Fig.3



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

Fig.1

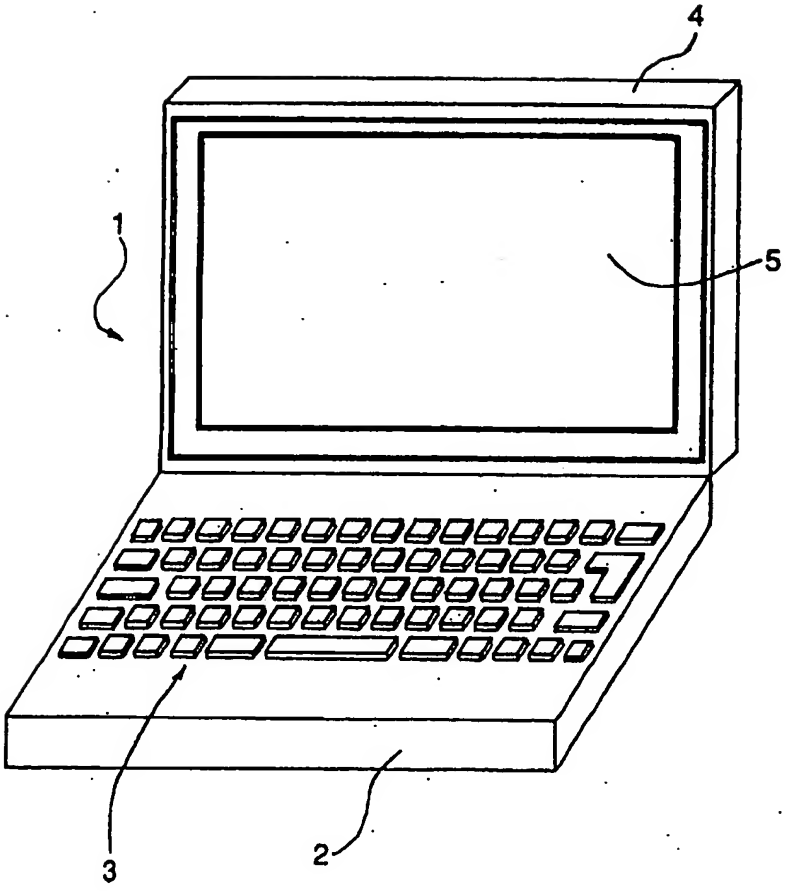

Fig.2

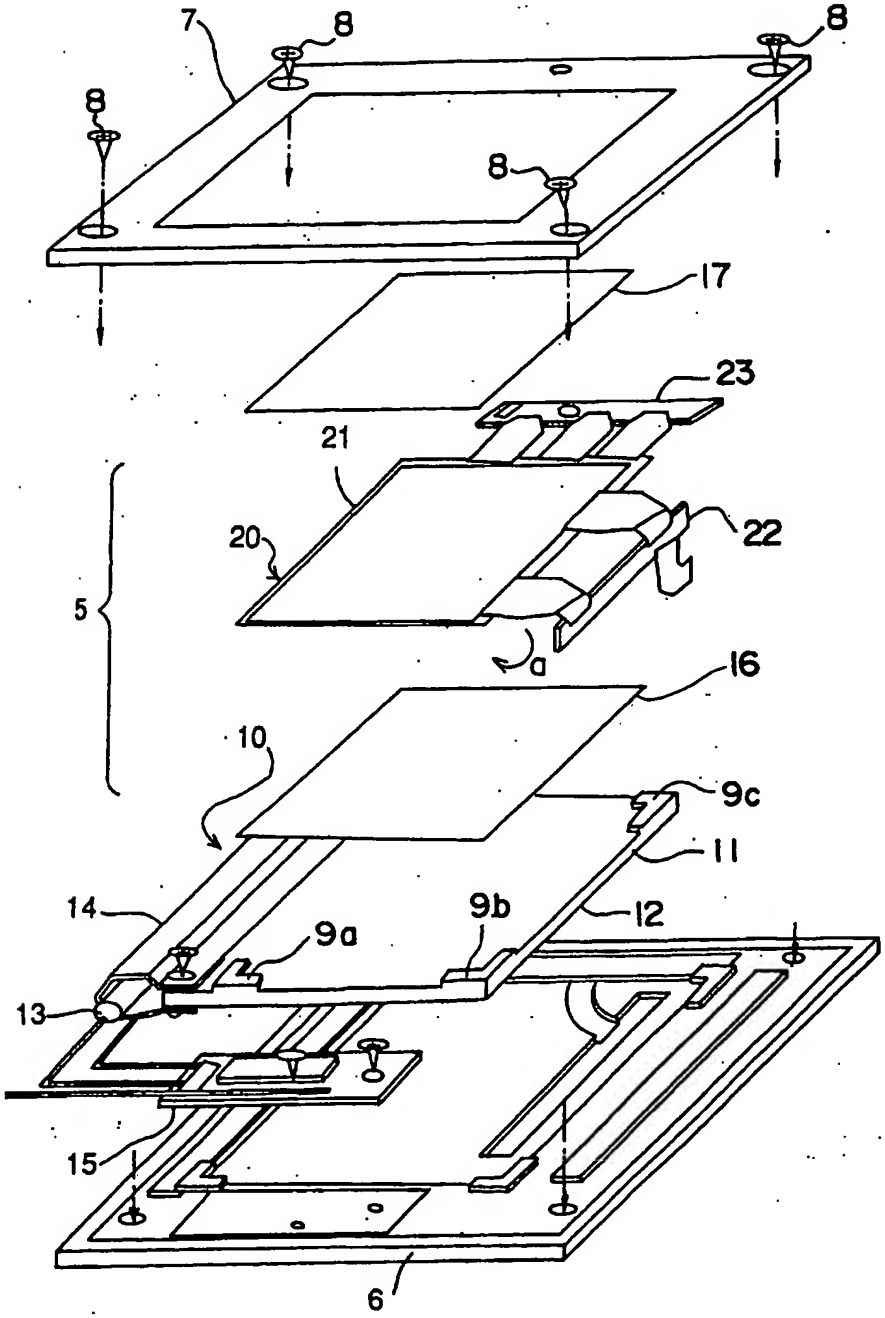

Fig.3

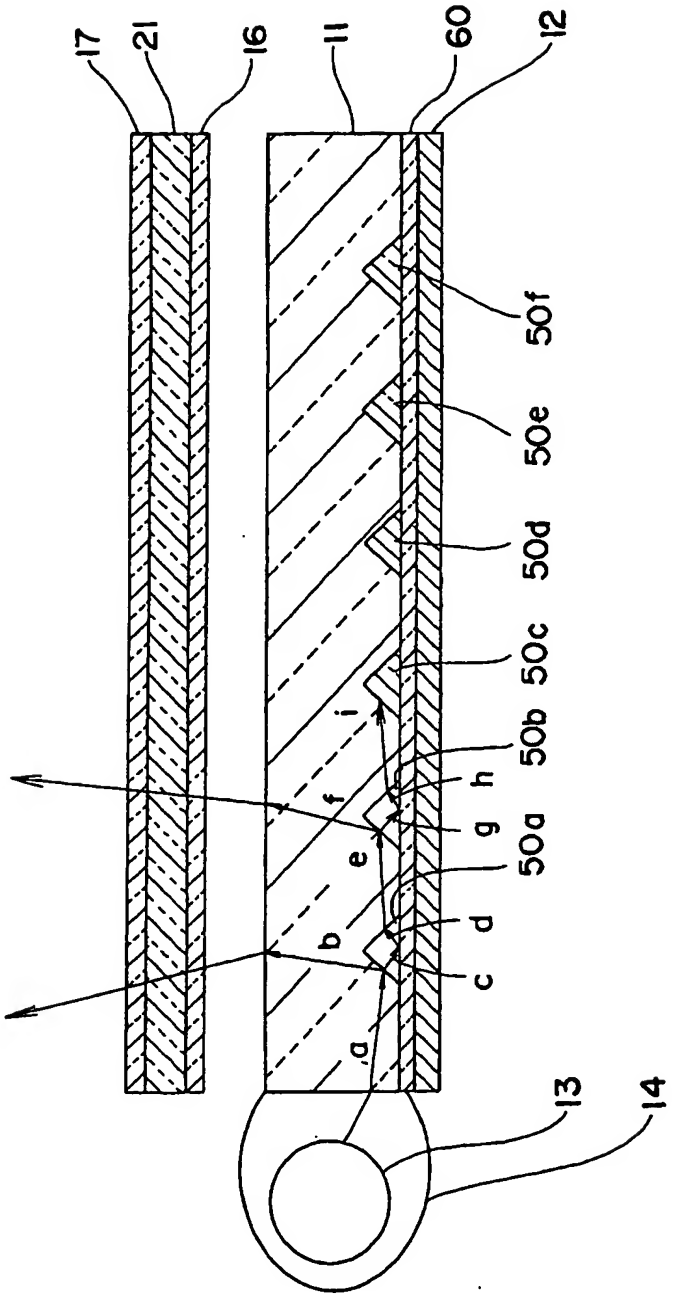

Fig.4

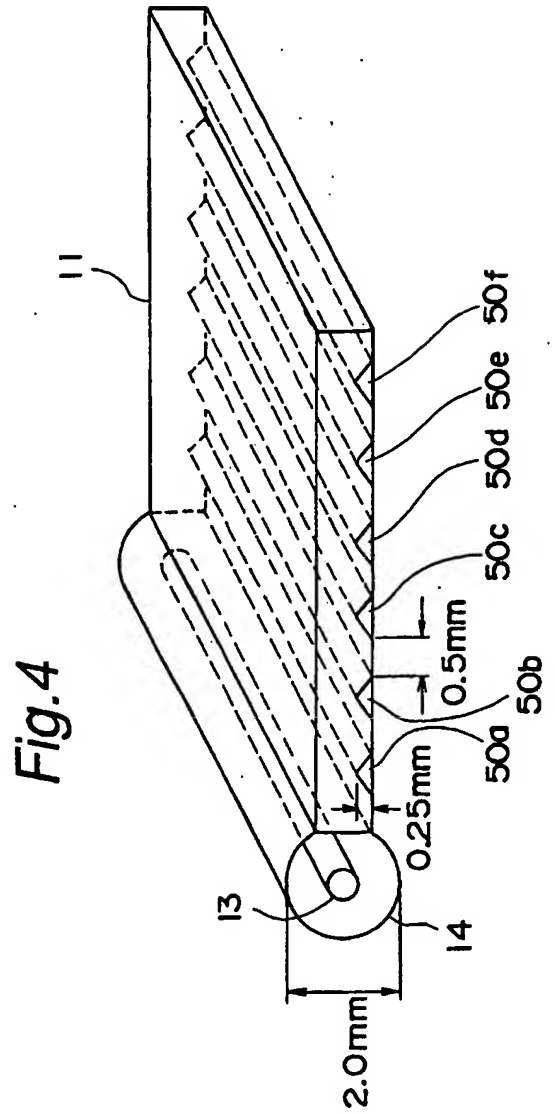

Fig.5

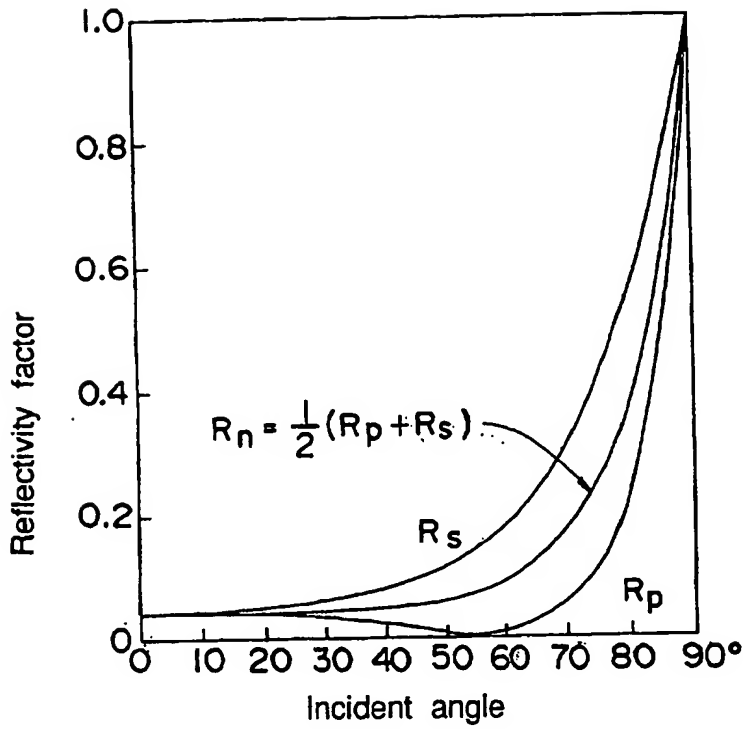
1.0
0.8
0.6
0.4
0.2
0
Reflectivity factor
$R_n = \frac{1}{2}(R_p + R_s)$
R_s
R_p
0 10 20 30 40 50 60 70 80 90°
Incident angle

Fig.6

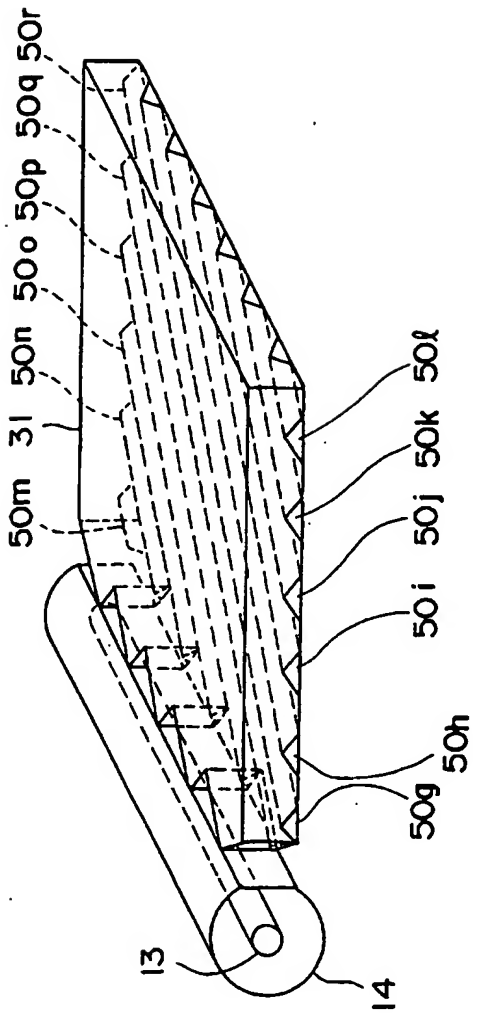

Fig.7

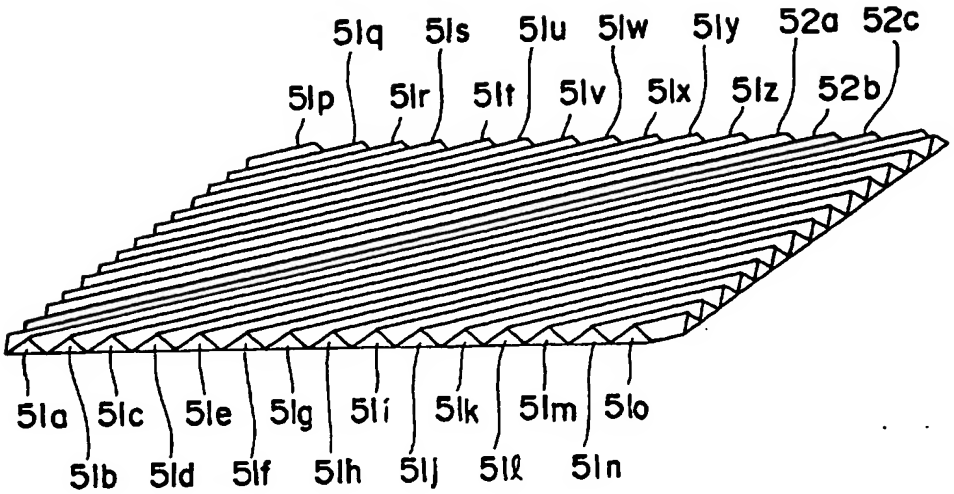
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Fig.8

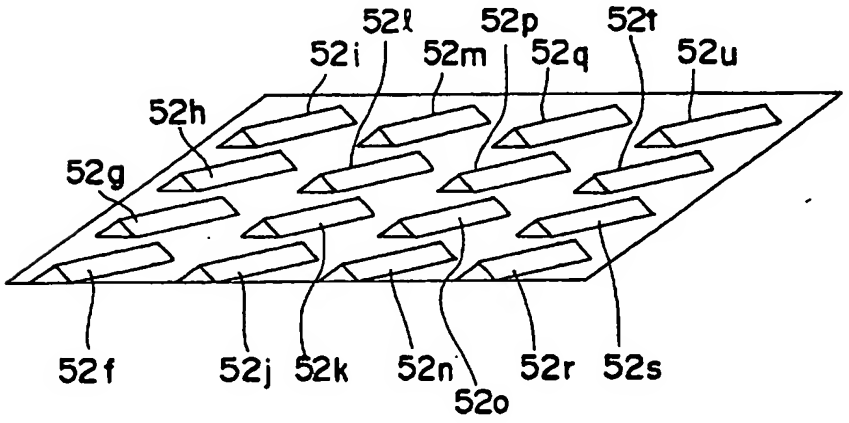
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Fig.9

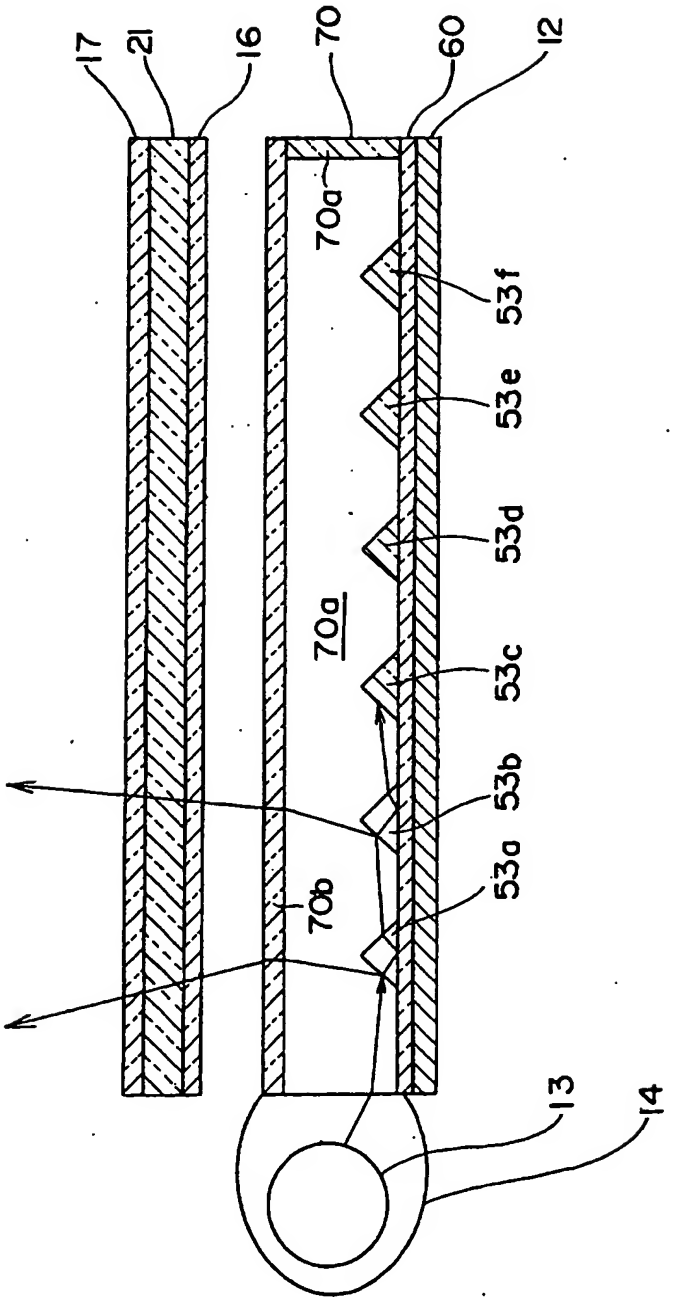


Fig.10

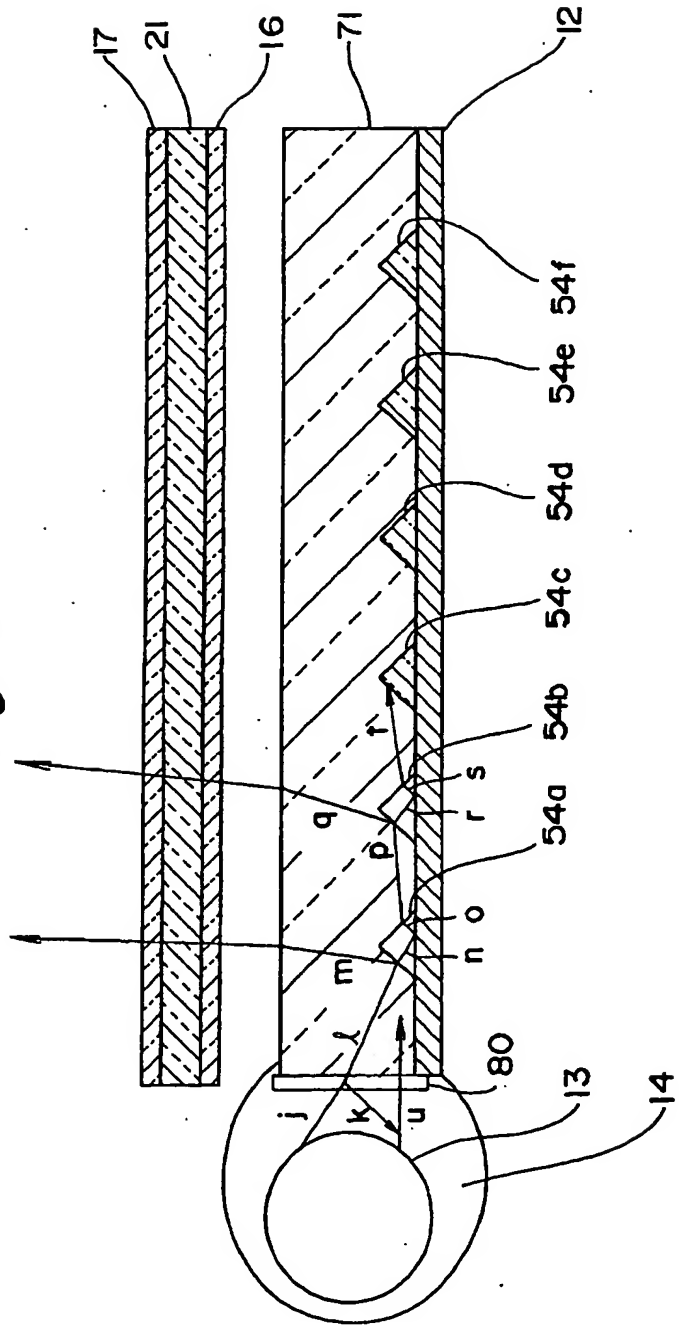


Fig.11A

Fig.11B

Fig.12 PRIOR ART

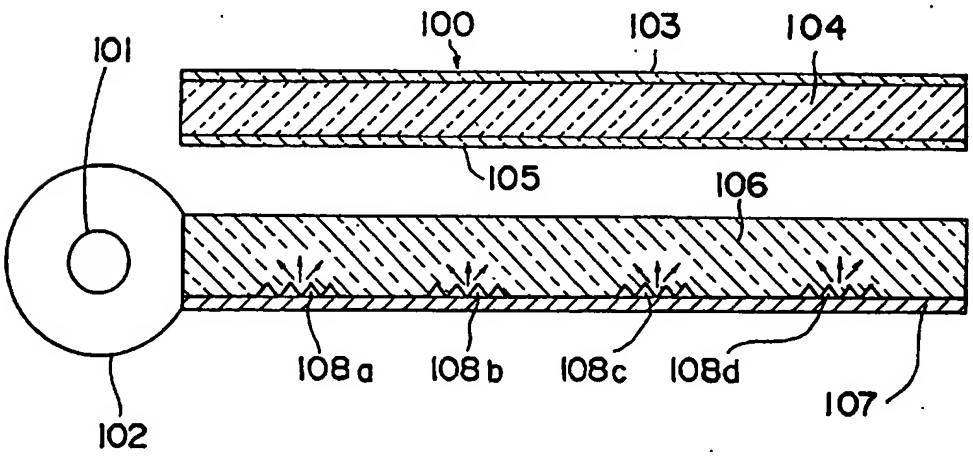
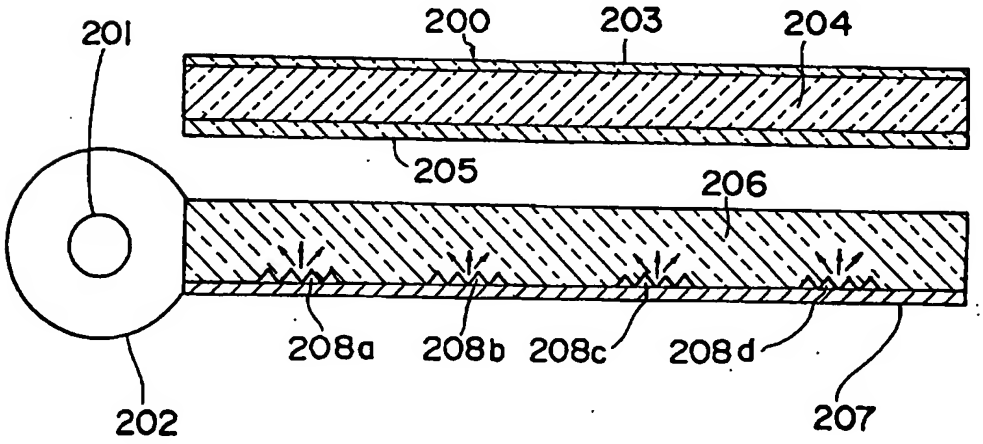


Fig.13 PRIOR ART



LIQUID CRYSTAL PANEL MODULE WITH A PLURALITY OF REFLECTING MEMBERS

The present invention relates to a liquid crystal panel display device used in a notebook personal computer or the like.

It is commonly well known that notebook personal computers (referred to simply as "notebook computers" hereinafter) and laptop wordprocessors use nearly rectangular liquid crystal display devices as lids thereof. A liquid crystal panel module is incorporated inside the liquid crystal display device, which consists of a light transmission-type liquid crystal panel unit and a backlight unit illuminating the liquid crystal panel unit from the rear. The backlight unit is constituted mainly of a light guide plate for guiding an illumination light to the liquid crystal panel unit and a lamp arranged at one side of the light guide plate.

A brightness of a liquid crystal display at the liquid crystal panel display device constituted as above is adjusted through the amount of the illumination light at the backlight unit. An electric power supplied to the lamp

in the backlight unit is increased if the brightness of a screen of the liquid crystal display is to be enhanced.

A TFT color liquid crystal panel used in the color liquid crystal display device nowadays exerts a light transmittance of as low as approximately 6-10%. The transmittance is determined almost by a multiplication of an aperture rate (50-80%) of a TFT array substrate, a transmittance (30%) of a color filter and a transmittance of a polarizing plate set at a bottom surface of the liquid crystal display panel. The transmittance of the polarizing plate of the conventional device is low, specifically, approximately 40%. As such, a relatively large luminance is required for the lamp to illuminate the whole face of the TFT color liquid crystal display panel bright, which necessitates a large power to be fed to the lamp.

For instance, while the 12.1-inch TFT color liquid crystal panel used in the notebook computer requires nearly 2W power for the backlight unit, this power is about 1/3 of a total power fed to the notebook computer.

In the case where the notebook computer is driven by a battery, it is preferable that the consumption of power in the backlight unit is small, and for reducing the power consumed in the backlight unit, it is necessary to increase the transmittance of the liquid crystal panel.

The liquid crystal panel module employed in the

conventional liquid crystal panel display device will be described hereinbelow.

Fig. 12 is a sectional view of a nearly rectangular liquid crystal panel module 100 used in a liquid crystal panel display device in the prior art. The liquid crystal panel module 100 consists of a backlight unit of nearly the same shape, i.e., nearly rectangular including a lamp 101, a reflector 102 and a light guide plate 106, and a liquid crystal panel unit of almost the same shape, namely, nearly rectangular having predetermined polarizing plates 103, 105 attached to a front and a rear faces of a liquid crystal panel 104. A reflecting sheet 107 is attached to a bottom surface of the light guide plate 106. A plurality of sawtoothed diffused reflection parts 108a-108d are provided in the reflecting sheet 107 to diffuse and reflect the light of the lamp 101.

The polarizing plate 105 attached to the rear face of the liquid crystal panel 104 passes only light of a predetermined polarization direction, and absorbs light of the other polarization directions. The polarizing plate 103 attached to the front face of the liquid crystal panel 104 passes only light in a direction parallel to or perpendicular to a polarization axis of the polarizing plate 105, with absorbing light of the other polarization directions.

In the above-described constitution, a circularly polarized lamp light including horizontal oscillation waves (p polarized light) and perpendicular oscillation waves (s polarized light) with respect to the bottom face of the light guide plate 106 are brought into the light guide plate 106 of the liquid crystal panel module 100. At least half of the lamp light is absorbed at the polarizing plate 105. Since the light is absorbed also within the light guide plate 106, the transmittance of light is decreased to as low as about 40% as discussed above.

Fig. 13 is a diagram showing the constitution of a liquid crystal panel module 200 proposed to solve the aforementioned problem. The liquid crystal panel module 200 comprises a backlight unit of a lamp 201, a reflector 202 and a light guide plate 206 and, a liquid crystal panel unit of a TFT color liquid crystal panel 204 held by a polarizing plate 203 and a polarizing separating film 205. The polarizing separating film 205 is a polarizing film of a reflecting type, for example, DBEF by Sumitomo 3M Co., Ltd. (registered trade name by Sumitomo 3M), passing light in a predetermined polarization direction and reflecting light in the other polarization directions. The polarizing plate 203 allows only light in a polarization direction parallel or perpendicular to a polarization axis of the

above polarizing separating film 205, with absorbing light in the other polarization directions. Similarly to the liquid crystal panel module 100, a reflecting sheet 207 is attached to a bottom surface of the light guide plate 206, with having a plurality of sawtoothed diffused reflection parts 208a-208d to diffuse and reflect the light from the lamp 201.

In the thus-constituted liquid crystal panel module 200, the light that cannot pass the polarizing separating film 205 is reflected totally to the light guide plate 206. The light reflected towards the light guide plate 206 is changed to be irregular in polarization direction at the diffused reflection part 208 at the lower surface of the light guide plate 206, then sent to the polarizing separating film 205 again. The polarizing separating film 205 passes, among the light input thereto, light in a predetermined polarization direction generated when the light is changed in the polarization direction at the diffused reflection part 208 and, reflects light in the other polarization directions. This reflection of light is repeatedly carried out in the light guide plate 206, whereby the amount of light passing the polarizing separating film 205 is increased, thereby decreasing a loss of the lamp light.

However, the polarizing separating film 205 is

complicated in structure and expensive as compared with general polarizing films, hence inviting a cost rise of the liquid crystal panel module 200.

The present invention has for its object to provide a liquid crystal panel module equipped with a backlight unit of a structure whereby a TFT liquid crystal panel can be illuminated inexpensively and efficiently.

In order to accomplish the above object of the present invention, a liquid crystal panel module is provided which comprises a backlight unit consisting of a light guide plate having a reflecting sheet at a lower face thereof, a lamp for projecting light from one side of the light guide plate and a reflector for condensing the light of the lamp to the light guide plate, and a liquid crystal panel unit having a polarizing plate at a lower face thereof and disposed on the backlight unit. A plurality of equilateral prisms are arranged between the light guide plate and the reflecting sheet constituting the backlight unit in a direction to be parallel to a polarization axis of the polarizing plate of the liquid crystal panel unit. The equilateral prism has a prism angle whereby an angle of incidence of the light guided from the lamp into the light guide plate becomes a Brewster angle.

The amount of light to be absorbed at the

polarizing plate at a bottom face of the liquid crystal panel unit is reduced greatly. Particularly, the liquid crystal panel module employs the equilateral prisms exerting the above-described prism angle in the light guide plate, and therefore, the light including an s-polarized light much can be directly sent to the liquid crystal panel unit while the absorption of light at the polarizing plate at the bottom face of the liquid crystal panel unit is suppressed. The liquid crystal panel unit is accordingly efficiently illuminated. Moreover, the liquid crystal panel module is constructed inexpensively, because an expensive reflecting-type polarizing film as in the conventional liquid crystal panel module is not employed.

According to a preferred embodiment of the present invention, a polarization rotating film is set on a face of the reflecting sheet at the side of the light guide plate which rotates a polarization direction of the entering light by a predetermined angle, and preferably, the equilateral prism has a larger index of refraction than that of the interior of the light guide plate. Owing to this, the light including much more s-polarized light is reflected to the liquid crystal panel unit. That is, the equilateral prisms having the larger index of refraction than the interior of the light guide plate and also the polarization rotating film provided between the bottom face

of the light guide plate and the reflecting sheet effectively work to improve a reflectance of the s waves directly reflected to the liquid crystal panel unit.

When a space part is provided in the light guide plate where the light guided from the lamp directly enters prism faces, the light guide plate is made hollow, so that the liquid crystal panel module becomes light-weight and reduced in cost.

According to a different preferred embodiment of the present invention, the liquid crystal panel module comprises a backlight unit consisting of a light guide plate having a reflecting sheet at a lower face thereof, a lamp for projecting an illumination light from one side of the light guide plate and a reflector for condensing the light from the lamp to the light guide plate, and a liquid crystal panel unit having a polarizing plate at a lower face thereof and disposed on the backlight unit, which further includes a reflecting-type polarizing film at a side face of one side of the light guide plate where the lamp is set so as to pass light of the same polarization direction as the polarizing plate, and a plurality of reflecting members at a bottom face of the light guide plate to directly reflect the light guided from the lamp into the light guide plate to the liquid crystal panel unit. In the constitution with using the reflecting-type

polarizing film at the side face of the light guide plate to which the light from the lamp is projected, as compared with the case where the reflecting-type polarizing film is set between the light guide plate and the liquid crystal panel unit, the backlight unit becomes lower in cost.

The present invention will become readily understood from the following description of preferred embodiments thereof made with reference to the accompanying drawings throughout which like parts are designated by like reference numerals and in which:

Fig. 1 is a perspective view of a notebook personal computer adopting a liquid crystal display device according to an embodiment 1 of the present invention;

Fig. 2 is an exploded perspective view of the liquid crystal display device;

Fig. 3 is a sectional view showing the constitution of a liquid crystal panel module;

Fig. 4 is a perspective view showing an arrangement of a reflecting member;

Fig. 5 is a graph of a relationship of an incident angle of light to a reflecting surface of the reflecting member and a reflectance;

Fig. 6 is a diagram of a modified example of the arrangement of the reflecting member;

Fig. 7 is a diagram of a modified example of the arrangement of the reflecting member;

Fig. 8 is a diagram of a modified example of the arrangement of the reflecting member;

Fig. 9 is a sectional view of the constitution of a modified example of the liquid crystal panel module;

Fig. 10 is a sectional view of the constitution of a liquid crystal panel module according to an embodiment 2 of the present invention;

Figs. 11A and 11B are diagrams of modified examples in shape of the reflecting member;

Fig. 12 is a sectional view of the constitution of a conventional liquid crystal panel module; and

Fig. 13 is a sectional view of the constitution of a conventional liquid crystal panel module.

According to a liquid crystal display device of an embodiment 1 of the present invention, a plurality of reflecting members (equilateral prisms) are provided within a light guide plate to reflect directly to a liquid crystal panel a light, among an illumination light from a lamp, which includes oscillation waves having an electric field oscillating in a perpendicular direction to a bottom surface of the light guide plate, that is, is polarized

light. Fig. 1 is a perspective view of a notebook personal computer 1 employing a liquid crystal display device 4 of the embodiment 1. The notebook personal computer 1 is constituted of a main body 2 having a keyboard 3 at an upper face and a CPU, a hard disk, etc. inside, and the liquid crystal display device 4 incorporating a liquid crystal panel module 5. The liquid crystal display device 4 is connected in a state to be openable/closable to the main body 2.

Fig. 2 is an exploded perspective view showing the structure of the liquid crystal display device 4 of Fig. 1. The liquid crystal panel module 5 is arranged at the side of an inner face of a metallic case 6 of the liquid crystal display device 4, over which a mask frame 7 is fitted. The metallic case 6, liquid crystal panel module 5 and mask frame 7 are clamped and united in one body by a plurality of screws 8 fastened from an outer face of the mask frame 7. The liquid crystal panel module 5 is comprised of a backlight unit 10 and a liquid crystal panel unit 20 layered one another. The case 6 is formed of, e.g., Mg or Mg series light alloy by die casting.

The backlight unit 10 has a light guide plate 11 for guiding an illumination light to the liquid crystal panel unit 20 and a fluorescent lamp 13 disposed at one side of the light guide plate 11. A reflecting sheet 12 of,

for example, a resin film coated with Ag is attached at the side of a rear face of the light guide plate 11. The constitution inside the light guide plate 11 will be detailed later. The lamp 13 is connected to a piezoelectric trans inverter 15 working as a high frequency power source. The lamp 13 of a polygonal section is surrounded by a reflector 14 which is opened only at one side facing the light guide plate 11. An inner face of the reflector 14 is formed of, for instance, a silver-plated thin brass sheet.

L-shaped ribs 9a, 9b, 9c, 9d are provided at four corners of an upper face of the light guide plate 11 although 9d is not illustrated in the drawing. A polarizing plate 16, a TN liquid crystal panel 21 and a polarizing plate 17 constituting the liquid crystal panel unit 20 are layered sequentially on the light guide plate 11 by the L-shaped ribs 9a-9d and held at a predetermined position in a state.

The liquid crystal panel unit 20 comprises the TFT liquid crystal panel 21 as a transmission-type liquid crystal panel held between the polarizing plates 16 and 17, a source printed circuit substrate 22 and a gate printed circuit substrate 23. The polarizing plate 16 transmits light of a predetermined polarization direction and absorbs light in the other polarization directions. The polarizing

plate 17 has a polarization axis in a direction perpendicular to the polarization axis of polarization plate 16. The source printed circuit substrate 22 is bent to turn to the rear side of the light guide plate 11, as indicated by an arrow a, after the liquid crystal panel unit 20 is fixed on the light guide plate 11. The source printed circuit substrate 22 is fixed to the case 6 in the above state. The case 6 has a recessed part which can receive the bent source printed circuit substrate 22, so that a face butting to the light guide plate 11 is flat.

Fig. 3 is a sectional view of the constitution of the liquid crystal panel module 5. As depicted earlier, the liquid crystal panel module 5 is obtained by setting the liquid crystal panel unit 20 of the TFT liquid crystal panel 21 held by the polarizing plates 16 and 17 onto the backlight unit 10 having the lamp 13, reflector 14 and light guide plate 11. The polarizing plate 16 on a bottom face of the liquid crystal panel 21 has a polarization axis in a direction perpendicular to an axis direction of the lamp when seen from above the liquid crystal panel 21.

A polarization rotating film 60 and the reflecting sheet 12 are attached to a bottom face of the light guide plate 16. The polarization rotating film 60 rotates the polarization direction of the entering light by 90°. Although described later in more detail, there are

arranged at a bottom part of the light guide plate 11 a plurality of reflecting members 50a-50f of equilateral prisms having a prism angle whereby the primary light from the lamp 13 enters with a Brewster angle (referring also to Fig. 4). These reflecting members 50a-50f are formed of a material of a higher index of refraction than a material of the light guide plate 11.

In the event, for example, the light guide plate 11 is formed of acrylic resin of an index of refraction n1=1.49, tantalum oxide Ta2O5 of an index of refraction n2=2.25 is used for the reflecting member 50. While a ratio of the indices of refraction n2/n1 becomes 1.51 in the above case, the ratio is preferred to be large, the reason for which will be discussed hereinbelow.

Fig. 4 is a perspective view showing a state of the reflecting members 50a-50f in the light guide plate 11. As described before, the polarizing plate 16 shown in Figs. 2 and 3 has the polarization axis perpendicular to the axis of the lamp. On the other hand, the reflecting members 50a-50f are arranged to be perpendicular to the polarization axis of the polarizing plate 16, in other words, parallel to the axis of the lamp. Each of the reflecting members 50a-50f is a transparent body having a uniform index of refraction n, more specifically, a prism of an isosceles triangular cross section of 0.25mm height,

120° vertical angle and 30° base angles. The reflecting members 50a-50f are spaced via 0.5mm. Generally, an angle defined by utilized two faces (prism faces), i.e., the aforementioned vertical angle is named the prism angle and a prism of the isosceles triangular cross section is a equilateral prism.

Fig. 5 is a graph of a relationship of an angle of incidence of light to a reflecting face of each reflecting member 50a-50f and a reflectance. Three curves in the graph represent respectively a reflectance Rs of oscillation waves (s polarized light) having an electric field oscillating in a perpendicular direction to a plane of incidence, a reflectance Rp of oscillation waves (p polarized light) having an electric field oscillating in a horizontal direction to the plane of incidence, and a reflectance Rn=(Rp+Rs)/2 of natural light.

For example, when the light enters the reflecting face of the reflecting member 50a-50f with an incident angle of 55°, the reflectance Rs of the light polarized in the perpendicular direction to the reflecting face is 0.2 and the reflectance Rp of the light polarized in the horizontal direction to the reflecting face is 0. Therefore, the reflected light at this time becomes a linearly polarized light polarized in the perpendicular direction to the reflecting face. The angle of incidence,

55° in the example whereby a ratio of reflectances of the p and s polarized lights is maximum is generally called a Brewster angle.

In order to improve the transmittance of light at the polarizing plate 16, it is preferred that the reflected light from the reflecting members 50a-50f include many polarization components agreeing with a polarization direction of the polarizing plate 16. The ratio of reflectances of the p polarized light and s polarized light at the Brewster angle is increased as the ratio n2/n1 of the index of refraction n1 inside the light guide plate 11 and the index of refraction n2 of the reflecting members 50a-50f is larger.

Therefore, a material having the index of refraction n2 as large as possible to the index of refraction n1 of the light guide plate is preferable for the reflecting members 50a-50f. Although Ta2O5 is used for the reflecting members 50a-50f in the embodiment, materials of high permittivity shown in Table 1 below that have a larger index of refraction than that of the light guide plate 11 and a high transmittance are also utilizable for the reflecting members 50a-50f.

Table 1

Material	Index of refraction	Transmission wavelength band(μm)
$Sr_{0.5}Ba_{0.5}Nb_2O_6$	2.27	0.4-6
TiO_2	2.58	0.4-5
$SrTiO_3$	2.38	0.4-5
Diamond	2.42	0.2-5
Ta_2O_5	2.25	0.35-10
ZrO_2	2.10	0.34-12
ZnS	2.30	0.4-14
Acrylic resin	1.49	0.3-10

The incident angle of light passing in the light guide plate 11 is distributed in a range of 0-45° to a parallel direction of the light guide plate 11, approximately 20° on the average. The reflecting member 50a-50f used in the liquid crystal panel module 5 is the equilateral prism of the prism angle 150° and accordingly the base angle of the equilateral prism is 15°. The angle of incidence of light is thus from 30 to approximately 75°. From the graph of Fig. 5, most of the reflected light is the linearly polarized light of the s polarized light in the perpendicular direction when the angle of incidence is 30-75°.

Since the equilateral prism of the prism angle 150° is employed as the reflecting member 501-50f of the liquid crystal panel module 5, the light is less absorbed at the polarizing plate 16, in other words, the transmittance at the polarizing plate is improved.

Referring back to Fig. 3, how the light projected

from the lamp 13 (indicated by the arrow a) enters the reflecting member 50a will be discussed in detail. The light projected from the lamp 13 is natural light. Supposing that the amount of the natural light is 1, the light is composed of 0.5 oscillation waves (p polarized light) showing the parallel oscillation direction of the electric field to the plane of incidence to the reflecting member 50a and 0.5 oscillation waves (s polarized light) having an electric field oscillating in the perpendicular direction to the plane of incidence. If the incident angle of light to the reflecting member 50a is 55°, a reflected light (shown by an arrow b) comprises 0 p polarized light and 0.1 s polarized light. The polarizing plate 16 passes only the linearly polarized light in the perpendicular direction to the reflecting face of the reflecting member 50a, with absorbing the light of the other polarization directions. In this case, however, the whole of the reflected light is allowed to pass through the polarizing plate 16.

Meanwhile, supposing that the light is never absorbed at the reflecting member 50a, a refracted light (shown by an arrow c) is constituted of 0.5 p polarized light and 0.4 s polarized light. The refracted light is, after passing the polarization rotating film 60, reflected at the reflecting sheet 12 and again passes the

polarization rotating film 60. A reflected light (of an arrow d) from the reflecting sheet 12 is rotated by 90° by the polarization rotating film 60 to be comprised of 0.4 p polarized light and 0.5 s polarized light. A projected light (of an arrow e) from the reflecting member 50a can always be an elliptically polarized light including a lot of s polarized light owing to the polarization rotating film 60.

As is understood from the above description, since the light guide plate 11 is provided with reflecting members 50a-50f, the light that includes less p polarized light and much s polarized light can be fed to the light polarizing plate 16. As a result, the amount of light absorbed at the polarizing plate 16 (p polarized light) is reduced and the transmittance of light at the polarizing plate 16 is improved. When the transmittance at the polarizing plate 16 is improved, the liquid crystal panel can be illuminated with a required brightness even if the amount of power supplied to the lamp 13 is small. For example, a drive time of a battery driving the notebook personal computer employing the liquid crystal panel module for the display can be extended.

Fig. 6 indicates an arrangement of a light guide plate 31 and reflecting members 50g-50r in the case where a polarizing plate 30 having a polarization axis inclined by

45° to the axis direction of the lamp is used in place of the polarizing plate 16. The reflecting members 50g-50r are arranged side by side in a direction perpendicular to a polarization axis of the polarizing plate 30. A sawtoothed part is provided at an end face of the light guide plate 31 where the lamp light enters. The sawtoothed part introduces the light from the lamp 13 after refracting by 45° so as to let the light enter perpendicularly to reflecting faces of the reflecting members 50g-50r. In the constitution as above, since the polarization axis of the polarizing plate 30 is inclined by 45° to the frame, right and left view angles are secured symmetrically even when general TN liquid crystal is used.

A shape and an arrangement of the reflecting members 50g-50r can be changed suitably in accordance with an index of refraction thereof, an index of refraction of the light guide plate 31, etc.

Figs. 7 and 8 represent other arrangements of the reflecting members 50g-50r in the light guide plate 31 different from Fig. 6. In Fig. 7, reflecting members 51a-51z, 52a-52c are set without any gap in the light guide plate 31. When the reflecting members are arranged without any gap as above, the light can be more uniformly reflected to the liquid crystal panel unit.

In Fig. 8, reflecting members 52f-52u are

scattered in the light guide plate 31. Since a count of reflecting members disposed in the light guide plate is reduced, the liquid crystal panel module is decreased in cost.

Fig. 9 is a sectional view showing the constitution of a modified example of the liquid crystal panel module 5 of the liquid crystal panel display device 4 in the embodiment 1. The same parts as those of the liquid crystal panel module 5 of the embodiment 1 are denoted with the same reference numerals and a duplicate description will be eliminated here.

The liquid crystal panel module in the modified example features a light guide plate 70 which has a space part 70a where the light from the lamp 13 directly enters prism faces of reflecting members 53a-53f. The light guide plate 70 is in such structure, e.g., that three side faces except one side face to which the light from the lamp 13 is introduced, and a face in touch with the liquid crystal panel 21 are fenced by an acrylic plate 70b, and moreover a reinforcing member 70c is provided at a face in touch with the polarization rotating film 60 which does not restrain the lamp light from entering the prism faces. A material of a higher index of refraction than that in the light guide plate 70 is used for the reflecting members 53a-53f.

For instance, if the index of refraction inside the light guide plate is n=1, acrylic resin of 1.49 index of refraction is used for the reflecting members 53a-53f. A shape and an arrangement of the reflecting members 53a-53f are equal to those of the reflecting members 50a-50f and the like.

In the above constitution, the reflecting members 53a-53f can be formed of material inexpensive and relatively small index of refraction. If acrylic resin is used, the reflecting members 53a-53f can be molded, and therefore the production cost is greatly decreased as compared with in the case of the other materials of Table 1. Besides, since the space part is provided in the light guide plate 70, the liquid crystal panel module becomes light-weight.

Fig. 10 indicates the constitution of a liquid crystal panel module according to an embodiment 2 of the present invention, in which the same parts as those of the liquid crystal panel module 5 of the embodiment 1 are designated by the same reference numerals to avoid a duplicate description. The liquid crystal panel module of the embodiment has, similar to the liquid crystal panel module 5 of the embodiment 1, an acrylic or hollow light guide plate 71 and reflecting members 54a-54f of a

predetermined material which is specified from an index of refraction in the light guide plate 71. Moreover, a reflecting type polarizing separating film 80 is interposed between an opening of the reflector 14 at the side of the light guide plate 71 and the light guide plate 71. The polarizing separating film 80 passes only s polarized light to the plane of incidence of the reflecting member 54 while reflecting lights of the other polarization directions. The polarizing separating film 80 is, by way of example, DBEF by Sumitomo 3M Co., Ltd. (registered trade name by Sumitomo 3M).

Among a light (of an arrow j) emitted from the lamp 13, the s polarized light perpendicular to a bottom face of the light guide plate 71 penetrates the polarizing separating film 80 (in a direction of an arrow l) and enters straight to the light guide plate 71. In contrast, the p polarized light in the horizontal direction is reflected at the polarizing separating film 80 (in a direction of an arrow k), irregularly reflected at the lamp 13 and reflector 14 thereby to be changed in polarization direction, and returned to the polarizing separating film 80 (in a direction of an arrow u). Accordingly, the light (of the arrow l) entering the light guide plate 71 becomes a linearly polarized light formed simply of the perpendicular s waves to the bottom face of the light guide

plate 71. Since the reflecting members 54a-54f set in the light guide plate 71 have flat reflecting faces, the polarization direction of lights (of arrows m, n, o, p, q, r, s, t, etc.) in the light guide plate 71 never changes. In consequence of this, the linearly polarized light of the s waves alone is brought into the polarizing plate 16, so that the absorption of light at the polarizing plate 16 is almost perfectly eliminated. Illumination efficiency of the TFT liquid crystal panel 21 by the lamp 13 is thus improved greatly.

Although the liquid crystal panel module uses the expensive reflecting type polarizing separating film in comparison with the general polarizing plate, the polarizing separating film 80 is attached only to an end face of the light guide plate 71 from which the light of the lamp 13 enters, unlike the conventional example of Fig. 13 wherein the polarizing separating film 205 is attached to the entire bottom face of the liquid crystal panel. The illumination efficiency of the TFT liquid crystal panel 21 by the lamp 13 is improved with a cost increase of the liquid crystal panel module restricted.

According to the liquid crystal panel module of the embodiment 2, different from the embodiment 1, the light entering the light guide plate 71 is the linearly polarized light composed only of s waves perpendicular to

the bottom face of the light guide plate 71. Therefore, instead of the reflecting members 54a-54f of equilateral prisms, a reflecting member of a triangular prism of a right triangular cross section shown in Fig. 11(a) or a reflecting plate 56 having a section as illustrated in Fig. 11(b) may be employed.

Although the present invention has been fully described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.

CLAIMS:

1. A liquid crystal panel module comprising:

a backlight unit having a light guide plate having a reflecting sheet on a lower surface of said light guide plate, a lamp for illuminating one side of said light guide plate and a reflector for condensing light irradiated from said lamp to said one side of said light guide plate;

a liquid crystal panel unit arranged on said backlight unit which is provided with a polarizing plate on a bottom surface of said liquid crystal panel; and

a plurality of equilateral prisms arranged between said light guide plate and reflecting sheet and in a direction parallel to the polarization axis of said polarizing plate, each of said plurality of equilateral prisms having a prism angle so that light guided into said light guide plate impinges to a surface of said equilateral prism at a Brewster angle determined from a material forming said equilateral prism.

2. The liquid crystal panel module according to claim 1 wherein an index of refraction of said material forming said equilateral prism is larger than that of a material forming said light guide plate.

3. The liquid crystal panel module according to claim 1 or claim 2 further comprising a polarization rotating plate arranged on a surface of said reflecting sheet facing said

light guide plate for rotating a polarization direction of the incident light by a predetermined angle.

4. The liquid crystal panel module according to any one of the claims 1 to 3 in which said light guide plate has a hollow space for making light from said lamp impinge directly to said plurality of prisms.

5. A liquid crystal panel module comprising:

a backlight unit having a light guide plate having a reflecting sheet on a lower surface of said light guide plate, a lamp for illuminating one side of said light guide plate and a reflector for condensing light irradiated from said lamp to said one side of said light guide plate;

a liquid crystal panel unit arranged on said backlight unit which is provided with a polarizing plate on a bottom surface of said liquid crystal panel;

a polarization film arranged on said one side of said light guide plate for passing light having a polarization direction the same as said polarizing plate; and

a plurality of reflecting members arranged at the bottom of said light guide plate for reflecting light guided into said light guide plate directly to said liquid crystal unit.

6. A liquid crystal panel module substantially as hereinbefore described with reference to Figures 2, 3 or 9 and Figure 4, Figure 5, Figure 6, Figure 7 or Figure 8 or Figure 10 and Figure 11 of the accompanying drawings.

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Application No: GB 9822939.6
Claims searched: 1 to 4

Examiner: Rosie Hardy
Date of search: 11 January 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): G5C (CHX) F4R (RCAA)

Int Cl (Ed.6): G02F 1/1335

Other: ONLINE: WPI EDOC

Documents considered to be relevant:

Category	Identity of document and relevant passage			Relevant to claims
X	GB 2272277 A	GEC	See pages 4 & 5 and figs.9 and 10	1 & 2
X	EP 0730187 A2	INTERNATIONAL BUSINESS MACHINES	See pages 3 to 10	1 to 4
A	EP 0632229 A1	MITSUBISHI	See whole document	
X	EP 0597261 A1	ASAHI GLASS	See whole document	1 to 4

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